FIELD EVALUATION OF METHYL ANTHRANILATE FOR DETERRING BIRDS EATING BLUEBERRIES

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Abstract: In many parts of North America, bird depredation is a major problem for growers of blueberry and other small fruit. Methyl anthranilate (MA) is an effective avian feeding deterrent in some situations, and we conducted a 3-state field trial to evaluate the efficacy of a formulated product, ReJeX-iT AG-36. On 5 0.4-ha plots in Oregon, Washington, and Michigan, we applied 56.8 L of ReJeX-iT (17.2 kg MA/ha) at weekly intervals for 21 days. Numbers of blueberries lost from tagged branches in treated plots did not differ from those lost from paired control plots. Furthermore, yields from treated and control plots did not differ. Residues of MA on fruit immediately after spraying were unexpectedly low ($\leq$115 ppm) and declined rapidly to <4 ppm 6 days postspray. At 3 of the 5 study sites, extensive leaf discoloration followed ReJeX-iT AG-36 applications. Innovative application technologies will need to be developed if formulated MA is to be effective as a bird deterrent in blueberries.

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Bird damage to small fruit and berry crops is a nationwide problem that results in millions of dollars of lost income annually (Besser 1985, Avery et al. 1992). In recent years, managing bird damage in blueberries, cherries, and other small fruit crops has become increasingly difficult without methiocarb (Mesurol) available as a bird repellent (Tobin and Dolbeer 1987). Although methiocarb appears to pose minimal lethal threat to target and nontarget species (Dolbeer et al. 1994), the previous registrations for its use on fruit crops lapsed when the manufacturer opted not to meet the request for additional data by the U.S. Environmental Protection Agency (Tobin and Dolbeer 1987, Avery et al. 1993).

With the loss of methiocarb as a bird management tool, there is a need for alternative materials that will safely and effectively deter avian depredators. One promising compound is MA, a fruit-flavored food additive approved for human consumption by the U.S. Food and Drug Administration that is offensive to all species of birds tested to date (Kare 1961, Mason et al. 1989). Although MA has proven effective as a feeding deterrent in a variety of situations (Cummings et al. 1991, Mason et al. 1991), its effectiveness as a bird repellent on fruit crops is in doubt. Some studies (Askham 1992) have reported successful reductions in bird damage to blueberries and cherries, while others have reported slight or no effects of MA treatments (Avery 1992, Curtis et al. 1994, Cummings et al. 1995).

The potential usefulness of MA for bird deterrence in fruit crops is unclear. Definitive results have not been forthcoming because various MA formulations, application rates, plot sizes, spray techniques, and evaluation procedures have precluded ready comparisons across studies. Thus, our objectives were to employ standardized field test procedures to assess the effectiveness of 1 MA formulation under various conditions in several locations, measure MA residues on fruit, and relate residues to estimates of bird damage. We selected an application rate of 17 kg MA/ha because an earlier, more limited field trial (Cummings et al. 1995) indicated temporary repellency at a slightly lower rate (16.1 kg/ha), and because the manufacturer of the test product advised that higher rates might be too costly (P. Vogt, PMC Specialties, Cincinnati, Oh., pers. commun.).

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METHODS

Study Sites and Application Pattern

We conducted the study in Oregon, Washington, and Michigan. The 2 Oregon sites (Breyman and Gabriel) are near Salem, while the 2 sites in Washington are at Mt. Vernon (Sakuma) and Lyndon (MEMBA). The 4 sites in Oregon and Washington are commercial berry operations. The Michigan site is the Trevor Nichols Research Station of Michigan State University near Fennville. Bluecrop was the variety grown at all sites except Gabriel where Meader, a parent of Bluecrop, was grown. Each test site consisted of 2 paired 0.4-ha plots that were the same age and at least 15 m apart. One of the plots at each site was randomly selected for treatment, the other served as an unsprayed control. At each location, additional blueberry acreage not involved in our study bordered our test plots.

The initial MA application to each treated plot occurred 7 days before the initial harvest. We prepared spray solutions by mixing 56.8 L of ReJeX-iT AG-36 (PMC Specialties Group, Cincinnati, Oh.) with 227 L of water according to the label provided. Growers sprayed the treated plots with an airblast sprayer or similar equipment, previously calibrated to deliver 700 L/ha.

Following the same procedures, a second MA application was made to each treated plot on day 7 immediately after the first harvest. Two subsequent harvests occurred on day 14 and day 21 after the initial spray, and the third MA application occurred immediately after the second harvest.

Estimating Bird Damage and Activity

We measured berry loss, determined plot yields, and recorded dropped fruit to estimate bird damage in treated and control plots. We recorded bird activity opportunistically.

Berry Loss.—At each study site, before the initial treatment, we randomly selected 50 blueberry bushes in each plot and marked the bases with numbered flagging tape. On each sample bush, we chose 1 outer main branch or cane. On the upper third of each selected cane, we randomly selected a branchlet holding 20 blueberries. If there were >20 berries, we removed the excess. We identified each branchlet with a numbered tag and recorded the number of berries present on each branchlet immediately before and 1, 3, 7, 14, and 21 days after the initial treatment.

After counting the berries on each branchlet, we picked all ripe berries from the branchlet, recorded the number picked, and also recorded the number of berries left on the branchlet. The observer also recorded the number of berries picked that had peck marks. We judged berries ripe if they were uniformly blue.

Yield.—In Oregon and Washington, treated and control plots were harvested by the growers 7, 14, and 21 days after initial MA application. Yields from each row of bushes in each plot were recorded separately. Because berries were harvested at regular intervals, we assumed that natural droppage was negligible and similar in treated and control plots.

In Michigan, after the second spray, we randomly selected 10 bushes in the treated and control plots. In each plot, we randomly designated 5 of the 10 bushes to be protected from birds with wire exclosures. Ripe berries on the 10 selected bushes in each plot were picked and weighed on days 9, 14, and 21 after initial application. We compared yields between open control and open treated bushes and between enclosed control and enclosed treatment bushes with t-tests.

Dropped Berries.—At the 2 Oregon sites and at the Sakuma site in Washington, we collected dropped berries in randomly selected rows in the treated and control plots. We did this on days 3–7, 9–12, and 14 at Gabriel; on days 5, 7, 9, 11, and 14 at Breyman; and on days 1–6 and 10–13 at Sakuma. We also recorded dropped

Table 1. Blueberries lost to birds from 50 marked branches of 20 berries each in control and treated 0.4-ha plots in Oregon, Washington, and Michigan. Treated plots were sprayed on days 0, 7, and 14 with ReJeX-iT AG-36 (142 L/ha).

Days after initial spray	Berries lost to birds									
	Oregon				Washington				Michigan	
	Ga[a]		Br		Sa		ME			
	T[b]	C	T	C	T	C	T	C	T	C
1	2	3	0	1	2	1	4	4	24	11
3	2	7	3	1	6	5	2	2	39	22
7	90	56	98	43	13	12	13	12	68	69
14	13	29	9	10	20	10	39	16	94	35
21	9	19	5	8	3	0	9	22	17	24
Total	116	114	115	63	44	28	67	56	242	161

[a] Ga—Gabriel, Br—Breyman, Sa—Sakuma, ME—MEMBA.
[b] T—treated plot, C—control plot.

fruit under bushes netted to exclude birds (5 at Gabriel and Sakuma, 4 at Breyman). Yields from the netted bushes were measured at the Gabriel and Breyman sites.

Chemical Analysis

Before each spray, we collected a 50-mL sample of the bulk formulation as it was poured into the spray tank, and then refrigerated it for subsequent analysis. We also collected 50-mL spray tank sample after the bulk formulation was diluted and 20–50 mL from the output of the spray equipment. We stored all samples in sealed, labeled polyethylene bottles that were kept in a cooler with ice until refrigerated at 4 C.

In each treated plot, we clipped 100-g samples of blueberries from 5 randomly selected bushes at 9 different times (different bushes each time): 1 day pretreatment; immediately after initial MA application; and 1, 3, 7 (before and after MA application), 14 (before and after MA application), and 21 days after initial treatment. We collected similar samples in each control plot 1 day pretreatment and immediately after each MA application on the treated plot. We clipped berry samples directly from the bush into polyethylene bottles that we then labeled, froze, and shipped to the Denver Wildlife Research Center for residue analysis (Primus et al. 1996).

Phytotoxicity

We estimated the extent of discoloration on leaves of plants in the treated plots in Oregon and Washington in 10% increments, with 0% indicating no leaf discoloration and 100% indicating that all of the leaves on the plant had some discoloration. We inspected 21 plants (3/row) in the treated and in the control plot at Breyman on days 7, 9, 11, 14, and 20. Similarly, we scored 22 plants (2/row) in the treated and control plots at Gabriel on days 9, 11, 14, and 21. We selected plants haphazardly by walking diagonally back and forth through the plots. In Washington, on days 3 and 5, we scored the foliage of every other plant marked for berry counts, 25 in each plot.

RESULTS

Berry Loss from Marked Branches

The number of berries lost from the 50 marked branches in each plot varied considerably among sites, but overall did not differ (t = 2.19, P = 0.094) between treated and control plots (Table 1). Across the 5 sites, mean loss of berries from marked branches was 11.7% (SE = 3.4%) in treated plots and 8.4% (SE = 2.4%) in control plots.

Yield

Plot yields varied because of the disparate ages of the plantings, but yields from control and treated plots did not differ (t = −0.78, P = 0.49) in Oregon and Washington (Table 2). Similarly, yields at the Michigan site did not differ between the treated and control plots for either the open (P = 0.170) or the enclosed (P = 0.067) sets of bushes (Table 3). At Gabriel, 5 netted bushes yielded 432 g/bush compared to 318 g/bush in the treated plot and 363 g/bush in the control plots. At Breyman, 4 netted plants yielded 2.7 kg/bush compared to 2.0 kg/bush in the treated plot and 2.2 kg/bush in the control plot.

Dropped Berries

At 3 sites, numbers of dropped berries did not differ (t = 0.37, P = 0.75) between treated

Table 2. Whole plot and row yields at 4 sites where bird damage was assessed June–July 1994. Treated plots were sprayed 3 times at weekly intervals with ReJeX-iT AG-36 (142 L/ha). Plots were harvested 7 days after the initial spray and just before the second and third applications.

		Row yield (kg)				Plot yield (kg/ha)	
		Treated		Control			
Site	Rows/plot	$\bar{x}$	SE	$\bar{x}$	SE	T	C
Oregon							
Gabriel	11	42.7	1.8	48.6	3.6	1,174	1,337
Breyman	7	294.5	10.4	311.0	8.2	5,154	5,442
Washington							
Sakuma	9	62.7	8.6	52.7	5.0	1,411	1,186
MEMBA	12	242.4	6.5	247.0	9.1	7,272	7,410

and control plots (Table 4). Furthermore, at Breyman and Sakuma the number of dropped berries/bush in the study plots approximated that from the netted bushes. At Gabriel, however, the number of dropped berries/bush in the study plots exceeded that from the netted bushes (Table 4). The Gabriel and Sakuma sites were comparable in age and yield, yet the dropped berry data suggests greater bird activity at Gabriel than at Sakuma.

Pecked Fruit

The number of ripe, bird-pecked fruit recorded on marked branches ranged from 1 in the treated plot at Sakuma to 31 in the treated plot at Gabriel (Table 5). Overall, there was no difference in numbers of pecked fruit between treated and control plots (t = 0.44, P = 0.68).

Phytotoxicity

At Breyman, estimated leaf damage increased from 18% (SE = 2%) on day 7 to 49% (SE = 4%) on day 11, and then decreased again to 19% (SE = 2%) on day 20 (Fig. 1). At Gabriel, estimated leaf damage increased steadily from 9% (SE = 3%) on day 9 to 18% (SE = 2%) on day 20. We noted discoloration on old and new foliage, and on all parts of the treated bushes, apparently everywhere that the ReJeX-iT spray penetrated. No damage occurred in either of the control plots.

In Washington, phytotoxicity was minor at MEMBA with mean leaf damage of 14% on day 3 and day 5. At Sakuma, scores were 60% (SE = 6%) and 63% (SE = 6%), indicative of extensive leaf discoloration. We also noted, but did not quantify, many dropped leaves on several bushes in the treated plot at the Sakuma site.

Chemical Analyses

Bulk formulation samples varied from 9.8 to 13.7% MA ($\bar{x}$ = 11.9%, SD = 1.2%). The manufacturer's product label listed MA content as 14.5%. Tank samples varied from 1.80 to 3.73% MA ($\bar{x}$ = 2.68%, SD = 0.49%), and did not differ ($F_{4,10}$ = 3.26; P = 0.059) from concentrations in the spray samples ($\bar{x}$ = 2.27%, SD = 0.43%).

After the initial ReJeX-iT AG-36 application, MA residues on berries ranged from 39.0 ppm (SE = 5.3) at Michigan, to 115 ppm (SE = 33.1) at Sakuma ($F_{4,20}$ = 3.09; P = 0.03). Residues 6 days post-treatment declined to 3.7 ppm (SE = 0.6) at Breyman and to <1.5 ppm at the other locations.

Bird Activity

We observed European starlings (*Sturnus vulgaris*), American robins (*Turdus migratorius*), and house finches (*Carpodacus mexicanus*) eating blueberries at every location. Cedar waxwings (*Bombycilla cedrorum*), common grackles (*Quiscalus quiscula*), and Brewer's

Table 3. Yields from 5 enclosed and 5 open bushes each in the control and treated blueberry plots, Trevor Nichols Research Station, Michigan. The treated plot was sprayed with ReJeX-iT AG-36 (142 L/ha) on 20 July, 27 July, and 3 August. Mean yields were not different between control and treated bushes (P = 0.170 for open, P = 0.067 for enclosed).

	Open (g/bush)				Enclosed (g/bush)			
	Control		Treated		Control		Treated	
Date	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
29 Jul	243	103	180	89				
3–5 Aug	1,377	350	1,223	361	1,483	251	1,266	255
10 Aug	1,100	321	611	292	1,066	209	727	190
Total	2,720	677	2,013	661	2,549	431	1,994	401

Table 4. Number of berries collected from beneath blueberry bushes in control and treated plots at study sites in Oregon and Washington, June–July 1994. Treated plots received 3 separate applications of ReJeX-iT AG-36 (142 L/ha). Birds were excluded from 4 netted bushes at Breyman and 5 each at Gabriel and Sakuma.

		Dropped berries/bush					
		Treated		Control		Netted	
Site	Days counted	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Breyman	5	4.3	1.0	4.7	0.8	4.3	3.1
Gabriel	10	7.5	2.9	6.0	2.2	3.0	1.9
Sakuma	10	0.7	0.2	1.1	0.2	0.6	0.4

blackbirds (*Euphagus cyanocephalus*) occurred regularly at some sites only. American goldfinches (*Carduelis tristis*) occurred commonly at Breyman and Sakuma, but we did not see them eat blueberries. Also, we observed Brewer's blackbirds feeding only on fallen fruit. Producers characterized bird pressure as "light" or "normal" compared to previous years.

DISCUSSION

Our results were consistent among sites and showed that ReJeX-iT AG-36 was ineffective as a bird repellent on blueberries. Our findings were also consistent with those from 2 sites in British Columbia where evaluations were performed similarly (Bitterlich 1994). The application rate of 17.2 kg MA/ha produced initial MA residues on the fruit up to 115 ppm, well below the levels (2,500–5,000 ppm) deterrent to cedar waxwings in cage trials (Avery et al. 1992). The low initial residues and the rapid post-application degradation of the MA rendered the treatment innocuous to depredating birds.

How to improve the effectiveness of MA as a bird deterrent on blueberries is not clear. Increasing the application rate seems impractical due to higher costs and potential phytotoxicity problems. In January 1995, ReJeX-iT AG-36 cost \$11.60/L (price list published by PMC Specialties Group, Inc., Cincinnati, Oh.). Thus, each weekly application of 142 L/ha theoretically cost \$1,647/ha. Most blueberry growers probably could not afford such an expense (D. Brazelton, N. Am. Blueberry Counc., pers. commun.). Phytotoxic effects of MA have been documented previously (Avery 1992), and although in this study the growers were not alarmed by the leaf discoloration, this undesirable trait would worsen if application rates were increased. Possibly, greater MA persistence on the fruit and more complete coverage on individual berries would improve repellency. This might be achieved by adding a surfactant or sticker (P. Vogt, PMC Specialties, Cincinnati, Oh., pers. commun.), but such improvement in efficacy has yet to be demonstrated.

The MA residues measured on blueberries do not correspond to those predicted by Hoerger and Kenaga (1972). According to their guidelines, a spray application of 1.12 kg/ha should yield residues on berries of 7 ppm 24 hours post-application. Thus, our application of 17.2 kg/ha should have produced 107.5 ppm MA, 1

Table 5. Number of bird-pecked fruit harvested from 50 marked branches (20 berries/branch) in each treated and control plot at 5 study sites, June–August 1994. Treated plots were sprayed 3 times each with ReJeX-iT AG-36 (each application 142 L/ha). Numbers of pecked fruit did not differ ($t = 0.44$, $P = 0.68$) between treated and control plots.

	No. of ripe, pecked berries	
Site	Treated	Control
Oregon		
Breyman	16	4
Gabriel	31	14
Washington		
MEMBA	7	5
Sakuma	1	12
Michigan	10	18
Total	65	53
$\bar{x}$	13.0	10.6
SE	5.1	2.7

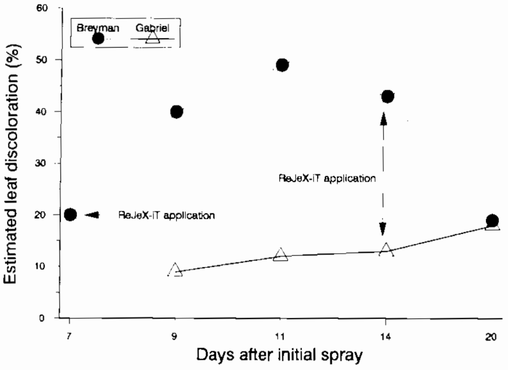

Fig. 1. Estimated extent of leaf discoloration on blueberry plants at 2 sites in Oregon following application of ReJeX-iT AG-36 for bird damage control. Sprays (56.8 L/plot) occurred on days 0, 7, and 14.

day post-spray. Mean 24-hour residues from the 5 study sites, however, were 18 ppm.

MANAGEMENT IMPLICATIONS

Netting is the only reliable method of bird damage control currently available to blueberry growers (Avery et al. 1992). Unfortunately, netting is expensive and impractical for many producers. Thus, continued development of safe, effective chemical repellents for fruit crop application is warranted.

The U.S. Environmental Protection Agency granted a tolerance exemption for the use of food-grade MA on blueberries, cherries, and grapes (Fed. Register, 26 Apr 1995, 40CFR-180.1143). This exemption allows additional efficacy evaluations to be conducted without the constraint, as we had, of having to destroy the treated crop. Thus, larger areas can be sprayed, and MA applications to 10-ha blocks might produce better deterrence than we obtained on 0.4-ha plots. At this time, however, there is no formulation or use pattern that has been consistently effective, so MA cannot be recommended with confidence to manage bird depredations on blueberries.

When is repellent application efficacious? If a grower anticipates 6,000 kg/ha yield, and if the price received for the crop is $1.00/kg, and if the loss to birds without repellent application is 20%, then $1,200/ha is the projected loss to birds. If repellent application is 75% effective, then gross savings of $900/ha potentially will result. The net savings will depend on the cost of the repellent treatment, but it must be <$900/ha for any savings to be realized. In this study, we applied 170 L of ReJeX-iT AG-36 to each treated plot at an approximate cost of $4,942/ha with no apparent bird damage reduction. Thus, if formulated MA products are to be useful for most blueberry producers, innovative application techniques that reduce costs and increase effectiveness need to be developed.

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